C5.7 Bearings LRFD

C5.7.1 General

C5.7.1.1. Policy overview

C5.7.1.2. Design information

C5.7.1.3. Definitions

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C5.7.2 Load and displacement application

C5.7.2.1. Dead

Methods Memo No. 24: Beam Design and Bearing Design, Distribution of Dead Load 2
4 September 2001

See C5.4.2.2.1.

C5.7.2.2. Live

Methods Memo No. 57: Abutment Piling Design, PPCB Bridges
5 November 2001

See C6.5.2.1

C5.7.2.3. Dynamic load allowance

C5.7.2.4. Thermal

C5.7.2.5. Shrinkage and creep

C5.7.2.6. Earthquake

See C6.6.2.10 for an overview of the 2008 Interim seismic requirements and their application in Iowa.

C5.7.3 Load application to bearings

C5.7.3.1. Load modifier

C5.7.3.2. Limit states

C5.7.3.3. Load path

C5.7.4 Bearing component analysis, design, and detailing

C5.7.4.1. Plain elastomeric pads

C5.7.4.1.1. Analysis and design

Methods Memo No. 209: Clarification for Plain Elastomeric Pad Design (Article 5.7.4.1.1 Analysis and design)
1 January 2009

There has been some confusion on the procedure for calculating beam slope for checking whether plain elastomeric pads may be used at a fixed bearing location. Therefore, when calculating whether uniform plain elastomeric pads or tapered pads can be used for a fixed bearing, the designer should not include the beam camber in the calculations. We realize that this is not consistent with the design procedure for laminated pads where the camber is included; however, the plain pad is confined once the concrete pier diaphragm is in place, so the decision was made to simplify the calculations.

This policy shall be used on all new bridge projects. If you have any question please check with me.

C5.7.4.1.2. Detailing

C5.7.4.2. Steel reinforced elastomeric pads

C5.7.4.2.1. Analysis and design

Methods Memo No. 70: Anchorage of Steel Reinforced Elastomeric Bearings
24 July 2003

Because Iowa precast beam manufacturers have begun adding galvanized steel plates at the ends of prestressed beams, beams simply placed on steel reinforced elastomeric bearings will have galvanized steel rather than concrete contact surfaces. Consequently the office has reexamined anchorage of elastomeric bearings.

The AASHTO Standard Specifications for Highway Bridges indirectly permit elastomeric bearings to be anchored by friction assuming an allowable coefficient of friction of 0.2 [AASHTO 14.6.6.4], without specifying the materials of the bearing contact surfaces.

U.S. testing since the late 1950s has indicated coefficients of friction above 0.2 for steel reinforced elastomeric bearings on concrete or steel surfaces. Coefficients of friction are lower for smoother concrete or steel surfaces and for higher compressive stresses. Usually elastomer against a steel surface has a lower coefficient of friction than elastomer against a concrete surface. Recent U.S. testing has indicated that the coefficient of friction for a smooth concrete surface will approach 0.2 at typical dead load compressive stress [Muscarella and Yura 1995].

No recent U.S. test results are available for steel reinforced elastomeric bearings on galvanized steel surfaces. However, for slip critical bolted steel connections, roughened galvanized steel faying surfaces generally have slip coefficients in the same general range as those for steel surfaces. The Specification for Structural Joints Using ASTM A325 or A490 Bolts [RCSC 1985] requires that roughening of galvanized steel faying surfaces be achieved by hand wire brushing.

The AASHTO LRFD specifications have indirectly lowered the allowable coefficient of friction to 0.167 (determined by dividing 0.2 by a load factor of 1.2) [AASHTO LRFD 3.4.1, 14.7.6.4]. There is no obvious reason for the lower coefficient of friction.

Based on published U.S. test results and additional information, the office will use an allowable coefficient of friction of 0.2, as indicated by the AASHTO standard specifications. The coefficient of friction shall be used to check friction anchorage of steel reinforced elastomeric bearings placed between

- Ordinary rough concrete bearing seats and concrete or roughened* galvanized steel plate bearing surfaces of precast prestressed concrete beams or
- Ordinary rough concrete bearing seats and galvanized steel plate-keeper bar assemblies (below precast prestressed concrete beams or steel girders).

If a bearing fails to provide sufficient slip resistance through friction, the bearing shall be restrained to prevent walking.

Steel reinforced elastomeric bearings placed between two steel or galvanized steel bearing surfaces shall be restrained with keeper bars, vulcanization, or other means at each surface. Anchorage by friction is unacceptable at either of the two surfaces.

Plain elastomeric bearing pads typically have relatively low coefficients of friction on concrete or steel surfaces, and the above policy does not apply to plain pads.

> * The bottom surface of the galvanized steel plate shall be roughened by hand wire brushing. Power wire brushing is not allowed.

References:

Muscarella, J.V. and Yura, J.A. (1995). *An Experimental Study of Elastomeric Bridge Bearings with Design Recommendations, Research Report 1304-3.* Center for Transportation Research, University of Texas at Austin, Austin.

Research Council on Structural Connections (RCSC). (1985). *Specification for Structural Joints Using ASTM A325 or A490 Bolts*, RCSC.

C5.7.4.2.2. Detailing

C5.7.4.3. Steel bearing parts

C5.7.4.3.1. Analysis and design

Methods Memo No. 22: Standard Rocker Bearings—Design Exception
22 October 2001

See C5.7.4.5.1.

C5.7.4.3.2. Detailing

C5.7.4.4. Anchor bolts

C5.7.4.4.1. Analysis and design

Methods Memo No. 113: Use of Anchor Bolt Wells
1 April 2009

Requests are sometimes received from contractors to use anchor bolt wells in lieu of preset or drilled in anchors. Requests for anchor bolt wells have been approved in the past and typically are:

1. Stay-in-place anchor bolt wells.

   The Office's preference is to use stay-in-place anchor bolt wells, and is typically formed with corrugated galvanized metal duct material.

2. Removable anchor bolt wells.

   The removable anchor bolt well has been approved by the Office but is not preferred. This method consists of a greased PVC sleeve that is removed following the casting of the concrete cap. Care must be taken by the contractor to thoroughly clean and roughen the void following the removal of the greased PVC sleeve.

Office policy will be to continue to specify drilled in or preset anchor bolt wells in the plans. Should the contractor request anchor bolt wells those will be considered on a case-by-case basis. When anchor bolt wells are used one fixed pier shall remain preset or drilled. Some situations where the Bridge Office has allowed the use of anchor bolt wells include:

1. Bridges with wide bottom flanges that did not permit drilling at anchor bolt locations.
2. Bridges with a high and varying skew combined with flared girders making it difficult to avoid the longitudinal reinforcing in the pier cap.

Submittals by the contractor for approval of anchor bolt wells shall include:

1. Stay-in-place-duct size and material specification.
2. Grouting procedure (typical a grout tube is inserted in the bottom of the well and the grout is pumped in).
3. Grout material specification.
4. A diagram showing how the pier cap reinforcing will be shifted to accommodate the anchor bolt wells.

C5.7.4.4.2. Detailing

Methods Memo No. 168: Layout of Anchor Bolt Locations
2 May 2007

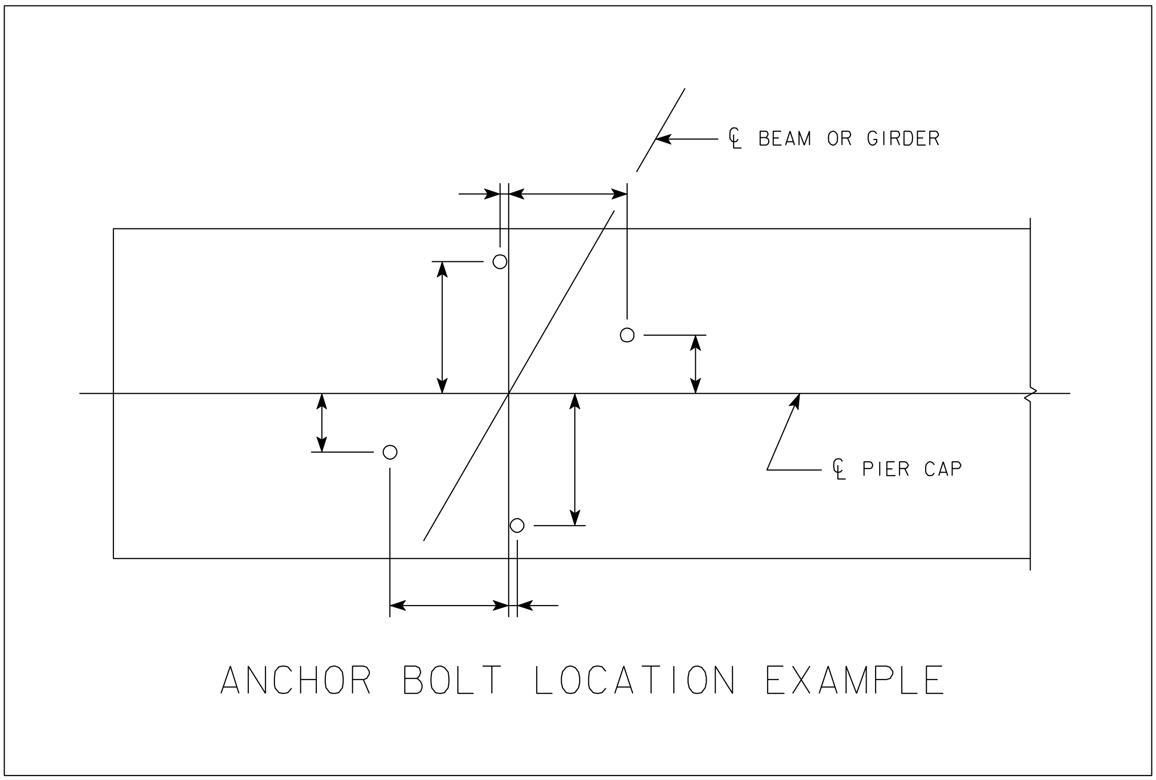
After discussions with the Office of Construction, the following policy change has been made for anchor bolt layouts on bridge plans. Effective on projects that have not yet been detailed anchor bolts locations shall be based on right angle dimensions with the centerline of the substructure unit. See attachment "A" for example layout.

The reason for this change is to reduce the chances of errors in locating the anchor bolts. Generally for bridge projects the survey controls that are established consist of the centerline of the approach roadway and the centerline of substructure units. The centerline of the substructure is the primary controls that the contractor uses. The office of Construction felt that contractors generally do not survey in the centerline of beams/girders due to the difficulty and potential inaccuracy. They locate the centerline of beam/girder intersection with the centerline of the substructure by measurements along the centerline of the substructure off the centerline of approach roadway.

Therefore, the layout (See Attachment A) is more common to the survey controls and more direct for the contractor during layout and construction.

If you have any questions please check with me.

Attachment "A"



C5.7.4.5. Fixed shoes, rockers, and sliding bronze plate bearings

C5.7.4.5.1. Analysis and design

Methods Memo No. 22: Standard Rocker Bearings—Design Exception
22 October 2001

OBS Standard Sheets 1008 and 1009 give details for rocker bearings designed according to the contact stress provisions of the 1992 Series of AASHTO Standard Specifications (Article 10.32.4.2). Those rocker bearings do not meet the more conservative contact stress provisions of the 1996 Series of AASHTO Standard Specifications (Article 14.6.1.4). As an example, R5 on OBS Standard Sheet 1009 is listed with a maximum reaction of 650 kips, whereas under the new contact stress formula the capacity would be limited to 563 kips (without a deduction for pintle holes).

At the time AASHTO changed the contact stress formula based on evidence of problems in some states, Iowa had no known problems with the standard rocker bearings. Based on Iowa's experience William Lundquist and John Harkin objected to the change, and AASHTO grandfathered the old formula for Iowa.

Thus rocker bearings on the OBS Standard Sheets 1008 and 1009 are approved under the 1992 Series of AASHTO Standard Specifications.

However, any new bearings shall be designed using the contact stress provisions of the 1996 Series of AASHTO Standard Specifications. The designer may consider the contact line to be the full width of the bearing without a deduction for pintle holes.

C5.7.4.5.2. Detailing

Methods Memo No. 168: Layout of Anchor Bolt Locations
2 May 2007

See C5.7.4.4.2.

Appendix for obsolete and superseded memos

Methods Memo No. 32: Elastomeric Expansion Bearings, New AASHTO Method A Rotation Formulas
13 August 2001

At the AASHTO committee meetings during May 2001 the rotation formulas for Method A were corrected for steel reinforced elastomeric bearings. The corrected formulas are less restrictive than the Method B rotation formulas used recently by the office to develop new bearing details, and the new formulas permit use of simpler details for many design conditions. Therefore, the office is modifying policy to accept the new formulas immediately.

Modify the Method A rotation formulas (14.6.6.3.5-1) for rectangular, steel reinforced elastomeric bearings to the following:

$$\sigma_{TL} \geq 0.5GS\left(\frac{L}{h_{ri}}\right)^2 \frac{\Theta_{m,x}}{n} \qquad \sigma_{TL} \geq 0.5GS\left(\frac{W}{h_{ri}}\right)^2 \frac{\Theta_{m,z}}{n}$$

Where:

h_{ri} = thickness of the i^{th} layer of elastomer (inches)

n = number of interior layers of elastomer, where interior layers are defined as those layers which are bonded on each face. Exterior layers are defined as those layers, which are bonded on only one face. [When the thickness of an exterior layer of elastomer is more than one-half the thickness of an interior layer, the parameter, n, may be increased by one-half for each such exterior layer. *This will not apply for the typical Iowa bearings that use an exterior layer one-half the thickness of an interior layer.*]

The new formulas generally will affect the height of expansion bearings shown on OBS Standard Sheets 4541A and M4541A and the details and sizes for similar bearings designed for stub abutments and steel superstructures.

If you have any questions please check with your section leader.

Methods Memo No. 92: Leveling Pads for Masonry Plates and Steel Bearings (Void, see CADD M0057 for standard sheets that have been modified to eliminate lead sheets.)
26 May 2004

A survey of state bridge bearing details indicates that state departments of transportation no longer are exclusively using lead leveling pads. Some states are listing options for the leveling pads below masonry plates, and some states have changed entirely from lead to elastomeric pads.

The most recent draft of the AASHTO/NSBA steel bridge bearing guide recommends an 1/8 inch thick preformed pad of elastomeric, cotton duck, or random fiber material and also recommends a maximum durometer of 70 for the pads. Lead is not among the options.

The reasons for the change from lead to elastomeric pads seem to be environmental and economic. In the United States there has been a movement away from use of lead in gasoline and paint because of lead's adverse effects on health. Although lead leveling pads are not likely to cause significant human exposure, use of an alternate material would eliminate any minimal exposure to construction workers. It is likely that alternate materials also would reduce cost of the leveling pads, although the reduction is insignificant in comparison with the cost of a bridge.

With this memo the office is changing policy to allow the option that leveling pads be plain neoprene, 1/8 inch thick and one inch larger in each dimension than the bottom surfaces of masonry plates or steel bearings. Leveling pads shall be of 50 durometer neoprene that meets the requirements of Article 4195.02 of the standard specifications. Leveling pads need not be designed for compressive stress because they are assumed to yield* and deform to fill the uneven surfaces of the concrete bearing seats.

One-eighth inch thick lead leveling pads will be permitted until standard sheets and other office documents are revised.

> *Recent testing has indicated that lead yields in compression at 1000 to 1500 psi. In the AASHTO bridge specifications, allowable compression stress for plain elastomeric pads is a maximum of 800 psi. AASHTO allowable concrete bearing stress is 1050 to 2100 psi for 3500 psi concrete and 1500 to 3000 psi for 5000 psi concrete, depending on the square root of a loaded area ratio. Therefore, it is likely that leveling pads of either lead or neoprene will yield under typical service conditions.

Until the standards can be updated the following note should be included on the bridge plans:

> THE CONTRACTOR WILL BE ALLOWED TO SUBSTITUTE 1/8 INCH NEOPRENE SHEETS WITH 50 DUROMETER HARDNESS IN PLACE OF THE 1/8 INCH LEAD SHEET ON THE BEARING DETAILS. THE NEOPRENE SHEETS SHALL BE 1 INCH GREATER IN LENGTH AND WIDTH THAN THE BOTTOM SURFACES OF THE MASONRY PLATES OR STEEL BEARINGS. PAYMENT FOR STRUCTURAL STEEL WILL INCLUDE NO DEDUCTION IN STEEL WEIGHT DUE TO ELIMINATION OF THE LEAD SHEETS AND/OR NO ADDITIONAL COSTS ASSOCIATED WITH THE ADDITION OF THE NEOPRENE SHEETS.

References:

AASHTO/NSBA Steel Bridge Task Group 9, Bearings. *Standard G9.1, Guidelines for Steel Bridge Bearing Design and Detailing.* Draft, November 19, 2003.

Riddington, John R. and Manjinder K. Sahota. "Mechanical Properties of Lead in Compression." *Journal of Materials in Civil Engineering*, Vol. 15, No. 4, August 1, 2003, pp 323-328.